IODP Expedition 352: Izu-Bonin-Mariana Forearc

Week 6 Report (31 August–6 September 2014)

Operations

Week 6 of Expedition 352 (IBM Forearc) continued with coring in Hole U1439C from 313.4 to 348.3 mbsf (Cores 17R to 20R). After accumulating 39.1 h on the rotary core barrel (RCB) bit, the drill string was brought to the surface on 31 August to change the bit. A new RCB bit was made up to the drill string and then run back down to the seafloor. While preparing the underwater camera for deployment, no video was being transmitted; the last of the fiber optic strands had failed. We then implemented a contingency plan to transmit video over one of the copper conductors in the existing cable. The camera was sent to the seafloor and Hole U1439C was reentered in 15 min (at 1405 h on 1 September). The camera was pulled back to the surface, and the bit was lowered to 319 mbsf, when it encountered an obstruction 30 m above the bottom of the hole. In the process of cleaning the hole, Core 21G recovered 0.1 m. Coring resumed from 348.3 to 465.3 mbsf (Cores 22R to 33R). At that point the second bit had accumulated 41.7 h of rotating time, so it was pulled back to the rig floor to be changed. After replacing the RCB bit, the drill string was lowered to the seafloor. The camera was sent to the seafloor and Hole U1439C was reentered at 0315 h on 5 September. The camera was pulled back to the surface, and the bit was lowered to 338.0 mbsf, when it encountered another obstruction. The hole was washed and reamed down to 416.3 mbsf when circulation was lost. The drill string had to be pulled all the way back to the casing shoe at 178 mbsf while fighting circulation and high torque problems. The bit was worked back to bottom, finally reaching 465.3 mbsf. In the process of cleaning 2 m of fill at the bottom of the hole, Core 34G recovered 0.5 m. Coring resumed from 465.3 to 515.8 mbsf (Cores 35R to 41R).

Science Results

Coring continued in Hole U1439C. Cores U1439C-14R to 25R are dominated by boninite pillow lava, with orthopyroxene ± olivine or clinopyroxene phenocrysts, together with intervals of highly olivine-phyric boninitic pillow lavas. Curved chilled margins on many of the larger pieces indicate that these are pillow lava flows with interpillow breccia. The highly phyric lavas appear to represent the cumulus-enriched lower portions of large pillow lavas; the upper portions and small pillows are commonly aphyric or sparsely phyric.

Cores U1439C-26R and 27R contain augite-phyric, plagioclase-bearing basalts that are distinct compositionally from the boninite lavas above and below. They are separated from the boninites by fault zones, and the basalt interval may contain an internal fault zone as well.

Core U1439C-28R contains boninitic pillow lava and pillow breccia, both commonly quite glassy. This is underlain by a mixed zone in Core 29R in which normal high-Cr boninitic lavas show magma mingling relationships with a more evolved low-Cr boninitic magma. The mingling occurs at the centimeter-scale, with blobs of dark gray, high-Cr lava within the lighter gray, low-Cr lava. Contacts vary from sharp to diffuse or gradational and, in places, it appears that the high-Cr lava has quenched against the, presumably lower temperature, low-Cr lava.

Cores U1439C-30R to 35R contain the same purple-gray aphyric to moderately phyric boninitic pillow lava encountered in Cores U1439C-14R to 25R. Small to medium sized pillows dominate, with less common interpillow breccias and hyaloclastite.

From the bottom of Core U1439C-36R and continuing down through Core 38R, the lavas are all aphyric basalts, with modal plagioclase in the groundmass and rare microphenocrysts of olivine. Pillow lava dominates, but some lavas are massive.

Based on a review of Cores U1439C-2R through 38R, together with all of the thin sections for these cores and the newly available ICP data and portable XRF (pXRF) data, the lavas in Hole U1439C have been divided into 11 lithostratigraphic units. The lithostratigraphic units are based on phenocryst assemblages and chemical compositions (from ICP-AES and pXRF), supplemented by the physical volcanology of the units (pillows, sheet flows, hyaloclastite breccias). Rocks above 475 mbsf (Cores U1439C-2R to 35R) are all boninitic (olivine and/or orthopyroxene phyric), except for Units 4 and 7, which comprise augite ± plagioclase-phyric basalts. Rocks below 475 mbsf (Cores U1439C-36R to 38R) are plagioclase-bearing basalts. Pillow lavas dominate the section, but hyaloclastites and massive lavas (sheet flows?) are common.

Portable XRF chemostratigraphic measurements were carried out on Cores U1439C-2R to 33R. The results of these measurements were vital in the identification of the igneous units. The 21 igneous rocks analyzed so far from Cores 2R–26R all show boninitic major and trace element compositions with up to 60 wt% SiO_2, high MgO (up to 16 wt%), and low TiO_2 (<0.5 wt%). ICP-AES analyses also identified two "transitional" basalts, one in Sample U1439C-2R-2, 33–36 cm, and one further downhole in Sample U1439C-10R-2, 13–19 cm (266 mbsf). All boninite samples recovered in Hole U1439C exhibit high LOI (2.7–16.2 wt%). Analyses of CO_2 and H_2O in the boninites demonstrate high contents of H_2O and low contents of CO_2 (<1.7 wt%) in the volatile budget of these samples.

In Cores U1439C-17R to 38R, 295 structures related to brittle deformation were observed. These structures consist mainly of tension fractures, slickensides, and cataclastic shear zones. Several faults were intersected at ~348–398, 427, 441, 466, and 476 mbsf. Some of the faults are characterized by abundant slickensides, whereas others are marked by zones of localized shear over centimeter-wide domains. The sense of slip on the inclined faults does not seem to be consistent. Both reverse and normal shear indicators were observed. A ~50 m wide fault zone (348–398 mbsf) is characterized by strong host rock alteration and disintegration, and comprises several centimeter-wide subhorizontal cataclastic shear zones and steeply dipping reverse shear fractures. The cataclastic shear zones are overprinted by subvertical extensional veins.

Microstructures were described in 40 petrographic thin sections. Calcite veins tend to be purely dilatational at shallow depths, but gradually evolve towards oblique tensional veins at depth, as shown by the oblique growth of calcite grains with respect to vein margins. The calcite grains also exhibit deformation microstructures that were not present at shallower depths. These microstructures include thin twinning, increasing in width with depth, curved twins, and subgrain boundaries indicative of incipient plastic deformation. The carbonate veins overprint zeolite vesicles and locally replace zeolite fills in the intersected vesicles. This overprint indicates that the carbonate veins postdate the growth of zeolite.

The physical properties of Cores U1439C-16R to 39R were measured this week. Magnetic susceptibility values of whole-round (WR) cores are <1000 IU with a peak of >1200 IU at 420 mbsf. A similar trend can be seen in the magnetic susceptibility values of core section halves. Density values of WR cores are stable at ~2.4 g/cm^3. Natural gamma ray values decrease gradually from 6 to <5 cps from 300 to 500 mbsf. Color reflectance parameters L*, a*, and b* are constant at 50, 2, and 3, respectively. *P*-wave values measured on discrete samples are between ~4000 and ~6000 m/s. Thermal conductivity is mostly in the range between 1 and 3 W/[m·K] with two low values of ~0.5 W/[m·K] at 330 and 450 mbsf. Discrete sample density values are ~2.5 g/cm^3 and porosity values are around 25 vol%.

Remanent magnetization measurements were made on working-half discrete samples and archive-half pieces. Archive-half SRM measurements were restricted to AF demagnetization. However, AF demagnetization does not work well on Hole U1439C samples as a result of the high magnetic coercivities possessed by some samples. As a result, most discrete samples are now being processed by thermal demagnetization. Many samples have Curie Temperatures ~550–575°C, indicating nearly pure magnetite as the magnetic carrier. In all, 77 archive-half pieces were measured with the SRM and 40 discrete samples were thermally demagnetized.

Education and Outreach

The following activities took place: (1) Facebook (https://www.facebook.com/joidesresolution) and Twitter (https://twitter.com/TheJR) posts with photo albums and short science summaries, (2) blogs on http://joidesresolution.org/ and scientists' sites, (3) four video conferences with Pound Middle School (Lincoln, NE), (4) GoPro footage collected by crew members showing work in the derrick, (5) podcast interviews, (6) submission of an article for a Michigan newspaper, and (7) another National Geographic blog.

Technical Support and HSE Activities

Technical staff supported science operations at Site U1439.

Laboratories:

- Updating the Serial Board driver appears to have solved communications issues on the D-Tek AF demagnetizer.
- Developed an Excel macro to reformat XRF data for upload into LIMS.
- Developed an Excel macro to identify problematic cells in sample request spreadsheets.
- Deployed beta version of Thermal Conductivity file converter for testing.
- A new sample tray was built to secure samples while cutting mini-cores.

HSE activities:

- Eye wash stations and safety showers were tested in the laboratories.
- An abandon ship and fire drill took place on 31 August.